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THE EUROPEAN PINE-SHOOT MOTH; A SERIOUS MENACE TO PINE TIMBER IN AMERICA.

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INTRODUCTION.

One of the most injurious insects to pine forests in Europe is a small orange-red moth, the larva of which eats out the new buds and kills or deforms the young twigs of pine trees, so as seriously and permanently to lower their timber value. This European pine-shoot moth, which is known under the scientific name *Evetria buoliana* Schiffermiller, has within very recent years been accidently introduced into America on imported European pine seedlings and has unfortunately become established in several widely separated localities in the eastern and middle western States.

Early last summer (1914), a correspondent of the Bureau of Entomology complained of a serious insect injury to European pines under his surveillance on Long Island, and sent examples of the injury and of the larvæ causing it; the latter could not be identified as those of any of our known American pine pests, and the writer was therefore authorized to visit the affected localities in order to ascertain the extent of the injury and to obtain sufficient live material for study and rearing. From this material a large number of moths emerged during the latter part of June and these were at once recognized as the famous European pine-shoot moth.

Subsequent surveys, undertaken by the bureau through Mr. Carl Heinrich and the writer, established the fact that the species has been repeatedly introduced on European nursery stock, and that it has become established in nurseries and parks in several localities scattered over nine States.

In view of the experience with other introduced European insects, and considering the very serious financial loss caused abroad annually by this insect, its introduction into this country gives just cause for alarm, because incalculable injury may result to the vast American forest interests if this insect is permitted to become generally established on our native pines.

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Some idea of the extent and permanent character of the injury which this insect is capable of inflicting may be gained from the illustration (Pl. I) of a European pine forest which has been infested by it for several years in succession, with the result that a majority of the tree trunks are so twisted and crooked that their value as timber is materially lessened.

HISTORY OF THE SPECIES IN EUROPE.

The species is a constant menace to pine forests in Europe and annually causes serious depredations, especially to young plantations of pine, in spite of continual preventive work against it. It has been the subject of much study and of an extensive literature from the time it was first described by Schiffermiller in 1776 to the present day. The species was named in honor of a Vienna entomologist, Baron Buol, who studied its injurious work during the latter part of the eighteenth century; since then numerous accounts have appeared of particularly severe outbreaks in many parts of Europe, from England to Russia, and from Scandinavia to southern France. It also occurs in Siberia.

One such outbreak in Denmark, in 1805–1807, is recorded by Niemann (1809).[1] This was so serious as nearly to cause pine culture to be abandoned in that country as hopeless. It is interesting to note that at that time the same preventive means were resorted to as are now employed against the insect, namely, the wholesale pruning and burning of all infested twigs.

The German forest entomologist, Ratzeburg, counted *Evetria buoliana* one of the most injurious forest insects and gave a detailed account (1840) of the life history, structure, and economic importance of the species. He mentioned especially an unusual outbreak in 1836–1838, which covered many parts of Europe. In the province of Furstenau the Rochesberg Mountain, which was covered with pines, became so seriously infested that it was under consideration by the authorities to burn it off and plant new trees. Other localities were only saved by strenuous systematic collecting of the infested twigs; thus, in the small province of Kesternich alone, 150,000 larvæ were gathered and destroyed.

Judeich and Nitsche (1895) state that the injury caused by *Evetria buoliana* is often fatal to the pine plantations. To quote from these authors, "If the attack is slight, it results in the branching of the tree, but if the attack is more severe and continued for several years, as we have seen it, then hardly any bud is spared and the pines become stunted into miserable small bushes from which numerous

[1] Dates in parentheses refer to "Literature," pp. 10–11.

branched shoots and large needle tufts stick out." These authors record many severe outbreaks and mention especially one in 1883–1885, in the Royal Forest Reserve, Pillnitz in Saxony, where nearly 75 acres of young pines planted in 1878 became infested to such an extent that hardly a shoot was spared, and in 1884 the entire plantation presented a pitiful, crippled appearance.

J. E. V. Boas (1898), who has made original investigations of the insect in Denmark, considers it one of the most injurious insects affecting forest trees. Among other outbreaks he mentions one in Jutland, Denmark, extending through several years around 1870, which "threatened the total destruction of the pine plantations."

The Belgian authority on forest insects, G. Severin (1901), regards *Evetria buoliana* as the most injurious insect to pines in Europe, and emphasizes the lasting injury to the timber resulting from even slight attacks of this insect.

All other European handbooks on entomology or on forestry contain similar accounts of this insect and express the same opinion as to its destructiveness to pine.

FOOD PLANTS.

Evetria buoliana is confined to pine and does not attack other coniferous trees, as spruce or larch, even though these grow alongside of the infested pines. While the species is most often mentioned on the yellow pine, or Scotch pine,[1] in Europe, because this is preeminently the forest tree of importance there, it attacks all species of Pinus indiscriminately, according to Ratzeburg and other authorities, and the American infestations have come in on European seedlings of the Austrian pine[2] and on mughus pine[3] quite as often as on Scotch pine.

According to Ratzeburg and Severin, it also attacks and is equally injurious to American white pine,[4] which is cultivated in Europe; and Mr. Carl Heinrich found the species on a small lot of another native American pine,[5] which was growing immediately surrounded by infested European pine seedlings.

These latter records are particularly significant, as they prove beyond question that the pest will spread to our native American pines if not prevented.

The species attacks mainly young trees between 6 and 15 years of age, but it is often excessively destructive to younger plantings and seedlings and injurious also to older trees, though trees of 30 years or older are rarely seriously affected.

[1] *Pinus sylvestris.*
[2] *Pinus laricis* var. *austriaca.*
[3] *Pinus montana* var. *mughus.*
[4] *Pinus strobus.*
[5] *Pinus resinosa.*

INTRODUCTION AND DISTRIBUTION IN AMERICA.

American nurseries have imported many thousands of pine seedlings annually from Europe, especially from France, Belgium, Holland, Germany, and England. Importations normally take place in the fall, winter, and early spring. At this time of the year the young larvæ of the pine moth lie dormant within the buds, so that an infestation is easily overlooked. It is evident that the pest has been present in a number of shipments of late years and that it thus has been introduced repeatedly into American nurseries. In a great majority of these cases, however, the species has been unable to establish itself and has died out during the first year. Many of the larvæ die from overheating en route, or from various other unfavorable circumstances incident to the handling and transplanting of the seedlings under different climatic conditions. Only by a combination of favorable conditions would the few surviving larvæ have been able to develop into moths and succeed in establishing the species in this country. This is probably the reason why the species as yet has become established in comparatively few American localities. It appears that such established infestation has taken place only in very recent years and especially within the last two years, or since the demand for European pines has become general.

Up to the present time the European pine moth has been discovered in only 32 nurseries and private estates, representing 20 localities in 9 States, namely:

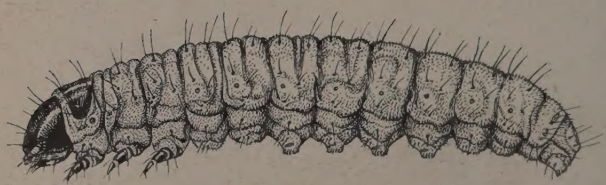
State.	Locality.	Discovered in—
Illinois	Chicago	Private grounds.
Do	Glenview	One nursery.
Do	Dundee	Do.
Do	Western Springs	Do.
Do	Deerfield	Do.
Do	Kenilworth	Two private grounds.
Do	Bloomington	One nursery.
Ohio	Tippecanoe City	Do.
West Virginia	Elm Grove	Do.
Pennsylvania	Pittsburgh	Private grounds.
Do	Philadelphia	One nursery.
New Jersey	Somerville	One estate.
New York	Long Island	Nine nurseries and estates.
Do	Tarrytown	One nursery and one estate.
Do	Elmsport	One estate.
Massachusetts	Dedham	One nursery.
Do	North Abington	Do.
Do	Worcester	Do.
Connecticut	New Canaan	Do.
Rhode Island	Newport	Two nurseries and one estate.

In none of these localities, except on Long Island, has the species existed for more than the last two years, and in most of them it has become established only within the last year.

But the survey for this insect has so far covered only about 60 localities, which could be reasonably suspected to harbor the pest because it was known that importations of European seedlings had

WORK OF THE EUROPEAN PINE-SHOOT MOTH (EVETRIA BUOLIANA).

Section of European pine forest showing deformations in the trunk of *Pinus sylvestris* resulting from several consecutive years' injury. (After G. Severin.)



STAGES OF THE EUROPEAN PINE-SHOOT MOTH.

Moth and full-grown larva; both greatly enlarged. (Original.)

[Drawings by Miss Mary Carmody.]

WORK OF THE EUROPEAN PINE-SHOOT MOTH.

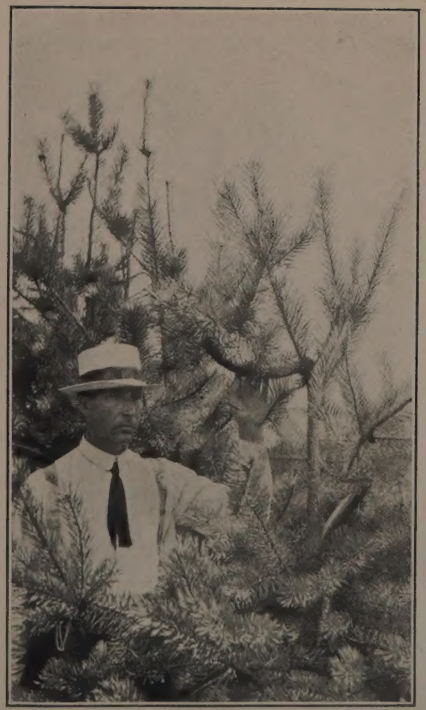
Fall work of the young larvæ in the buds of *Pinus sylvestris*. (Original.)

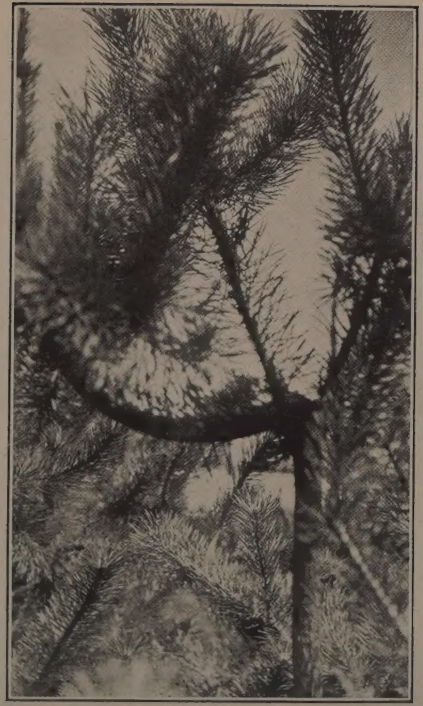
WORK OF THE EUROPEAN PINE-SHOOT MOTH.

Malformations in pine resulting from injury by this pest. (Original.)

WORK OF THE EUROPEAN PINE-SHOOT MOTH.

Twisted growth of European pines caused by the work of this insect. (Original.)





WORK OF THE EUROPEAN PINE-SHOOT MOTH.

Typical first, second, and third years' growth of pine, after the primary injury by this insect, known as "balonnette" or "posthorn." (Original.)

[Photographs by Mr. H. C. Sands, of the New York Department of Agriculture.]

taken place, and the indications are very strong that the pest has become established in several other widely distributed localities, either by direct importation from Europe or by distribution from infested American nurseries. This is particularly to be suspected of localities where large importations and plantings of European pines have been made.

As yet the pest has been found only in nurseries and private parks supplied by these infested nurseries. In no case has it yet been found on forest trees in America. The species is therefore at present mainly a nursery problem in this country and consequently may yet be controlled and possibly even eliminated by proper measures under Federal and State supervision. That this condition can not long endure and that the pest, if not checked, will soon multiply and spread to native pines outside of nurseries and pass beyond the possibility of elimination is clearly indicated by all the evidence on hand.

LIFE HISTORY.

In Europe the moths (Pl. II, upper figure) issue in July, sometimes as early as the end of June, and in the warm evenings they swarm around the pines in large numbers. During the day they sit quietly on the branches, as can be ascertained by giving the tree a sharp jolt, which will cause the moths to fly out. When the insect sits still on the food plant it is not easily discovered, for the apparently striking orange-red color blends well with the natural surroundings and therefore must be classed as a protective coloration. Early in August the eggs are laid singly on the new buds for next year's growth, the terminal cluster of buds being nearly always chosen for oviposition. The young larva soon hatches and eats its way into the bud, making itself a roomy cell by devouring the live inside part. It attains a length of only a few millimeters during the fall months, and overwinters within the hollow bud. At this stage its presence is easily overlooked, though a trained eye will discover a small exudation of pitch over the entrance hole differing from the normal exudation of the buds. (See Pl. III.)

In May, as soon as the sap begins to rise in the trees, the larva leaves its winter quarters and bores into the bud next thereto, in turn destroying this and as many others as it needs for food. As the remaining buds adjoining begin to grow into young shoots the larva attacks them. It eats the entire inside of the youngest shoots and these consequently die. The more developed shoots are injured only on one side, and these sometimes continue to grow, but are bent downward at the injured spot. The larva (Pl. II, lower figure) feeds only on the soft growth on which the needles have not yet appeared, and by the time the needles have developed all, or nearly all, of the shoots in the infested cluster have become dead or injured. The

buds. (See Pl. III.)

larva then makes a silk-lined chamber within one of the hollow shoots and here it pupates. After about three weeks the spiny pupa pushes itself half way out through the dry wall of its chamber and the moth, or adult, issues.

The full life history of the species in America has not been ascertained, because a full year has not elapsed since it was first discovered here. While in the main it is the same as in Europe, a very distinct difference has already been noticed, due to the longer and warmer summer and fall in this country. In Europe the young larva attacks only one bud and attains very little growth before it enters the dormant winter season, but in the warmer climate of America the larva eats out two, three, or more buds and attains nearly half of its growth before winter. This, of course, tends to make the species even more injurious here than it is in Europe.

While it is altogether probable that the species has here only one generation annually, as in Europe, the possibility is not absolutely excluded that on account of the longer season it may eventually develop two generations annually like the allied native species. This, of course, would greatly increase its power for injury.

CHARACTER OF INJURY.

During the entire spring the infested twigs are very noticeable by reason of the dead and injured buds and young shoots, and the empty pupa skin sticking out of the destroyed shoot is also a familiar and easily noticed sight during the summer months; but the extent of the injury caused by this insect is only realized later in the season, when the new growth is found to be either quite destroyed or permanently injured.

As may be gathered from the foregoing account of the life history, each one of these insects does very considerable damage, not only by destroying a large number of buds and young shoots but by injuring the adjoining shoots which remain and which normally should supplant the destroyed leaders; thus the trees are permanently disfigured. These injured shoots bend downward and outward and afterwards grow upward again in a curve, in the attempt to continue the normal upward growth of the tree. This results in a characteristic malformation (Pls. IV, V, VI), so familiar in European pine forests that it has a popular name in each country—as "posthorn" and "waldhorn" in Germany and Holland and "baionnette" in France, while the few examples which have so far occurred in America have suggested the name "Dutch pipe" to those who have noticed it. This injury does straighten out somewhat during the successive years' growth, but never can be fully remedied and will always be noticeable and a serious detriment to the timber (Pl. I). Injury of this character is the result even when the species is present in only small numbers, the

repeated infestation of the leading twigs during several consecutive seasons producing additional malformations which result in a much distorted tree of little commercial value. If the pest becomes more abundant, then the trees are transformed by the effect of the injury into unsightly crippled bushes with no commercial value.

DESCRIPTION.

THE ADULT.

(Pl. II, upper figure.)

The European pine-shoot moth is a small, gayly colored moth, about one-half inch long and measuring about three-fourths of an inch across with the wings extended. The head and its appendages and the thorax are light orange-yellow, and the abdomen is dark gray. The forewings are bright ferruginous orange, suffused with dark red, especially toward the tips, and with several irregular, forked anastomizing, silvery crosslines and costal strigulæ; the hindwings are dark blackish brown. The legs are whitish, the anterior ones reddish in front.

THE EGG.

The egg is very small, flat, whitish in color, and is laid singly at the base of a bud. Dissection of a female abdomen proves that upwards of a hundred eggs are laid by each female; this is a rather greater fecundity than is normal in this group of insects.

THE LARVA.

(Pl. II, lower figure.)

The young larva is dark brown with deep black head and thoracic shield, the latter divided by a narrow central line. The body of the older larva becomes somewhat lighter, but is still much darker than the larva of any of our allied native species. The full-grown larva is two-thirds of an inch long.

THE PUPA.

The pupa is stout, robust, light chestnut brown with darker head and back. The wing covers reach to the end of the fourth abdominal segment. The abdominal segments are armed with rings of short, sharp, blackish-brown spines.

ALLIED AMERICAN SPECIES.

There are in this country several indigenous species closely allied to *Evetria buoliana*, and like it confined to pine. Some of these already constitute a serious problem and periodically do considerable

damage to pine forests and more often to pine nurseries. They are the more capable of injury because there are two generations annually and they thus have two chances each year to accomplish their damaging work. None of these native species can, however, even with this advantage, be compared in destructiveness to the European species just introduced. This is partly due to the larger size of the introduced species and to the greater voracity of the larva, but is mainly due to the difference in the attack, which causes a different reaction of the tree.

The larva of the native species of the genus confines itself to a single twig and finds its food within this or within a single bud, or at most a few buds. This bud or twig dies, but the tree responds with the natural growth of the next set of buds and very often recovers from the injury without permanent disfigurement. The resulting injury to the trees is serious only when these native species are present in unusually large numbers. Moreover, each of the native American species is more or less confined to a single or a few species of Pinus, but the European pine-moth thrives indiscriminately on all species of Pinus and has consequently a greater chance to become excessively abundant. While several of the native species are continually of some economic importance and periodically become a serious menace even to larger trees, it is mainly when they occur in large numbers in nurseries that they become really troublesome. Large trees become checked in their growth by the loss of terminal twigs, but are not necessarily seriously deformed in their future growth, although an undesirable forking of the tree top is a quite common result.

On the other hand, the larva of the European pine-shoot moth is very voracious and not only destroys a number of buds and young sprouting shoots by eating their interior, but it invariably damages the remaining shoots in the cluster by nibbling their bases on the inner side. The subsequent growth of these injured shoots, in the effort to supplant the destroyed leader, causes greater permanent injury to the value of the tree than if they were entirely removed.

NATURAL ENEMIES.

Evetria buoliana in Europe is, to some extent, kept in check by a large number of parasitic enemies. As early as 1838 Hartig[1] recorded 14 ichneumonid wasps and 1 tachinid fly[2] which he had reared from pupæ of the pine-shoot moth. It has since been ascertained that there are several other parasites; among the ichneumonids Ratzeburg considered the following three, which he himself had reared, as the more important: *Pristomerus vulnerator* Panz., *Cremastus interruptor* Grav., and *Orgilus obscurator* Hald.

[1] See "Literature," p. 10. [2] *Actia pinipennis* Fallen.

To promote the good work of these parasites specially constructed rearing houses have been erected in Europe during bad outbreaks of the pine moth. The infested twigs are collected in these small houses, which permit the escape of the parasites but not of the moths.

It is reasonable to suppose that some of the native parasites on some of the native species of Evetria will in time also attack *Evetria buoliana* in this country—in fact, parasitized larvæ have already been observed—but these native parasites can not be relied upon to keep in check their natural hosts, the American pine moths, which sporadically become very abundant and injurious in spite of the parasites, and presumably will be less effective in controlling the newly introduced host.

METHOD OF CONTROL.

The larva of the European pine-moth is so effectively protected within the buds that it can not be reached by any insecticide, and the only method of combating it is that used in Europe for more than a hundred years, namely, the pruning and destruction of the infested buds and twigs together with the larvæ they contain. Such hand picking is practiced every year in the government-controlled forest reserves of Europe.

This pruning must be done while the insect is within the twigs, and while it may be done throughout the entire year, except during the midsummer months when the insect is in the adult stage, it can be most profitably done in the fall and winter months while the young larvæ are yet within the undeveloped buds, because the pruning at this time will enable the secondary set of buds to develop in the spring without delay. The only drawback to the collecting of the larvæ in the fall and winter is that the infested buds are then less noticeable than in the spring when the injury is further developed. A little practice, however, soon enables instant recognition of the infested buds, even by an unskilled laborer; the slight exudation of pitch at the base of the bud covering the entrance hole of the larva (Pl. III) is very characteristic and easily recognized when once known.

In the spring, when the buds develop into young shoots, the injury is very much more apparent, and anybody can then distinguish the infested twigs at a glance. For this reason it is advisable to have the trees gone over again in the spring, so as to remove any infestation which has been overlooked in the fall. In America the work of the larva in the fall (September, October, and November) has progressed far more and is much more easily discovered than is the case in Europe, where the larvæ have attained very small proportions and

have attacked only one or two buds before the winter resting period intervenes.

The fact that this species is stationary during the greater part of the year and only found within definite parts of certain kinds of trees, namely, in the next year's buds of pines, makes effective control work much easier than is the case with insect pests which are general feeders and which are not confined to definite parts of the food plant, as, for example, the gipsy moth or the brown-tail moth. While the European pine-shoot moth is confined to nurseries and private parks and has not spread to the native pines, it should prove a comparatively easy task to eradicate the species absolutely within any limited area. At the present time it would even seem possible completely to stamp out this dangerous pest in America, and forestall the infestation of our native pine forests, provided that the danger of new infestation is removed. But when once the species has multiplied sufficiently to become generally distributed on the native pines the possibility of eradication will be past.

SYNONYMY OF EVETRIA BUOLIANA SCHIFFERMILLER.

Tortrix buoliana Schiffermiller, Syst. Verz. d. Schmett., p. 128, 1776.
Coccyx buoliana Treitschke, Schmetterlinge von Europa, vol. 8, p. 140, 1830.
Tortrix (*Coccyx*) *buoliana* Ratzeburg, Die Forst-Insecten, vol. 2, p. 202, 1840.
Retinia buoliana Guénée, Europaeorum Microlepidopterorum index methodicus, p. 46, 1845.
Coccyx buoliana Herrich-Schäffer. Bearb. d. Schmetterlinge von Europa, vol. 4, p. 221, 1849.
Evetria buoliana Meyrick, Handbook of British Lepidoptera, p. 470, 1895.
Evetria buoliana Rebel, Catalog der Lepidopteren des palaearctischen Faunengebietes, T. II, No. 1851, 1901.

LITERATURE.[1]

1776. Schiffermiller, I. Systematisches Verzeichniss der Schmetterlinge der Wiener Gegend. Wien.
Original description of *Evetria buoliana*.

1809. Niemann, E. Forststastistik der Danischen Staaten, Altona.
Describes outbreak in Denmark in 1805–1807, and the collecting of larvæ in the effort to control the species.

1838. Hartig, T. *Tortrix buoliana*. *In* Jahresberichte über die Fortschritte der Forstwissenschaft und forstlichen Naturkunde, Jahrg. 1, Heft 2, p. 267–268, Berlin.
Records the rearing of 15 species of parasites from *Evetria buoliana*.

1840. Ratzeburg, J. T. C. Die Forst-Insecten, T. 2, p. 202–207, Taf. XIV, fig. 4. Berlin.
Detailed account with illustrations of the life history, work, economic importance, remedies, natural enemies, and literature of the species, with notes of severe outbreaks in Germany, 1835–1838.

[1] This is not intended to be a complete bibliography of *Evetria buoliana;* a large number of special articles have appeared in various publications in Europe, and every handbook on insects or forestry contains more or less exhaustive accounts of this pest.

1895. Judeich, J. F., and Nitsche, H. Lehrbuch der mitteleuropaischen Forstinsektenkunde, Bd. 2, p. 1004–1008. Wien.

Condensed (5 pages), life-history and economic importance with original figure of the injury done by the species.

1897. Lovink, H. J., and Ritzema Bos, J. Schade in jonge dennen bosschen teweeg gebracht door rupsen uit het bladrollergeslacht *Retinia* Gn. ("dennenknoprups" "dennenlotrups" "harsbuilrups"). *In* Tijdschr. Plantenziekten, Jahrg. 3, Afl. 4, p. 83–133, figs. 6, pls. V–VII, Oct.

Detailed account of the species and its injury, with colored plates.

1897. Severin, G. Insectes. Extrait du Catalogue détaillé et illustré du Pavillon des eaux et forêts à l'Exposition internationale de Bruxelles-Tervueren, p. 46–49, pl. X. Bruxelles.

Contains short illustrated account of *Tortrix* (*Retinia*) *buoliana* Schiffermiller and its injury: Plate I of the present paper has been copied from this article.

1898. Boas, J. E. V. Dansk Forstzoologi. Copenhagen.

Condensed life history, injury, and references, with original observations and figures.

1898. Hess, R. A. Der Forstschutz, ed. 3 enl., v. 1, p. 492–494, figs. 174–175. Leipzig.

Condensed handbook information on *Tortrix* (*Retinia*) *buoliana* Schiff.

1901. Severin, G. Le genre *Retinia*, Pyrale des pommes, des bourgeons, de la résine. *In* Bul. Soc. Cent. Forest. Belg., t. 8, p. 598–605, 674–685, 2 pls., 7 figs.

Monographic account of the three most important injurious species of the genus *Evetria* in Europe, with text figure and colored plate of *Evetria buoliana*. It should be noted that the larva figured under and credited to *Evetria buoliana* belongs to *Evetria resinella*, figured on the next colored plate, and vice versa.

1912. Gillanders, A. D. Forest Entomology, ed. 2. Edinburgh and London.

Condensed handbook information.

1913. Nüsslin, O. Leitfaden der Forstinsektenkunde, 2. neubearb. und verm. Aufl., p. 417–418, figs. 350, 352. Berlin.

Condensed handbook information on *Grapholitha* (*Evetria*) *buoliana* Schiff.

1914. Busck, August. A destructive pine-moth introduced from Europe (*Evetria buoliana* Schiffermiller). *In* Jour. Econ. Ent., v. 7, no. 4, p. 340–341, pl. IX, August.

First notice of the pest in America.

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